ASSESSMENT OF NORTHUMBERLAND STRAIT SCALLOP STOCKS AND REVIEW, 1978 TO 1981

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ABSTRACT

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Landings in the Northumberland Strait scallop fishery during 1981 increased significantly compared to those of 1980; by over 100% in Lobster District 7b1. Landed price increased by almost 25%; high returns made scalloping attractive to licensed fishermen who had not participated in the fishery in previous years. Average CPUE changed by -15, -6, and +16% in the western, central, and eastern regions of Northumberland Strait, respectively, while the number of active fishermen increased by 18, 63, and 75% from 1980 levels.

Recent landings are at a low level and stock recruitment is below average, particularly in the western region of Northumberland Strait. Declines in the number of recruits have been identified by resource surveys and are supported by fishery data (catch age composition, meat counts, and distribution of fishing locations). The need for conservative exploitation strategies is urgent; otherwise the area may experience a stock collapse.

Key words: deep-sea scallop, Gulf of St. Lawrence scallop fishery, scallop stock assessment, fishery management.

RÉSUMÉ

Robert, G. and G.S. Jamieson. 1982. Assessment of Northumberland Strait scallop stocks and review, 1978 to 1981. Can. Tech. Rep. Fish. Aquat. Sci. 1150: v + 37 p.

Les débarquements de pétoncle en provenance du détroit de Northumberland ont augmenté d'une façon significative en 1981, une hausse supérieure à 100% dans le district-homard 7bl. La valeur des prises au débarquement s'accrut de près de 25%, ce qui a incité plusieurs pêcheurs, détenteurs de permis, à pratiquer cette pêche bien qu'ils n'y avaient pas participé activement auparavant. Les PUE moyennes dans les secteurs est, central et ouest du détroit de Northumberland changèrent dans la proportion de +16, -6, et -15% respectivement, tandis que le nombre de pêcheurs actifs augmentait de 75, 63, et 18% par rapport aux niveaux de 1980.

Au cours des dernières années les débarquements sont à la baisse et le recrutement des stocks opère sous la moyenne tout particulièrement dans la région ouest du détroit de Northumberland. Des diminutions importantes du nombre de recrues ont été relevées au cours des inventaires de stocks et ont été vérifiées par les données de pêche telles que la composition d'âge des captures, les comptes de chair et la distribution des lieux de pêche. Des mesures pour une exploitation conservatrice s'imposent afin de prévenir la disparition des stocks.

INTRODUCTION

The Northumberland Strait scallop fishery is a relatively small fishery in the Maritimes, with recent average annual catches lower than historical levels of 200 t of meats (Fig. 1). The regional profile of this fishery is high because of the active participation of over 300 fishermen from the three Maritime provinces (New Brunswick, Nova Scotia, and Prince Edward Island), the organization of these fishermen into effective associations, and the frequent poor performance of other local fisheries (Anon., 1981). Inshore fishermen typically exploit a number of species (e.g. lobster, herring, cod); and as such, it is difficult to manage each fishery in isolation. The magnitude of landings from each fishery, except perhaps lobster, may be a better reflection of relative fishery productivity ($ return per unit effort) than stock status. Since scallops command a high price per unit weight, any major increase in abundance is intensively exploited by fishermen.

Since the late 1970's, positive efforts have been made by fishermen through an advisory committee to initiate optimal management of scallop stocks. From a state of no management a few years ago, measures were taken to regulate participation in the fishery under a limited-entry system of licenses, and fishing seasons were established (Table 1). However, other important regulations, such as the allowable meat count per unit weight at landing to optimize yield, were approved at the regional level (Maritimes) but encountered lengthy delays before becoming official. These regulations were not in place for the 1981 fishing season which partially precluded optimal management of the scallop stocks.

This report presents an assessment of scallop stocks based on both resource survey and commercial fishery data. The paper reviews the recent characteristics of the Northumberland Strait scallop fishery and presents management strategies for the scallop fishery considered as a single fishery.

METHODS

Resource surveys were conducted in 1981 in all three regions of Northumberland Strait (Figs. 2-4). The number of stations assigned to each survey region was determined from the combined distribution by area of the 1979 and 1980 commercial catch, as obtained from log records. Each area was assigned to one of three catch strata as in Jamieson et al., (1981b); stations were randomly assigned to fishing areas. The numbers of stations surveyed in the western, central, and eastern Strait were 56, 43, and 60, respectively.

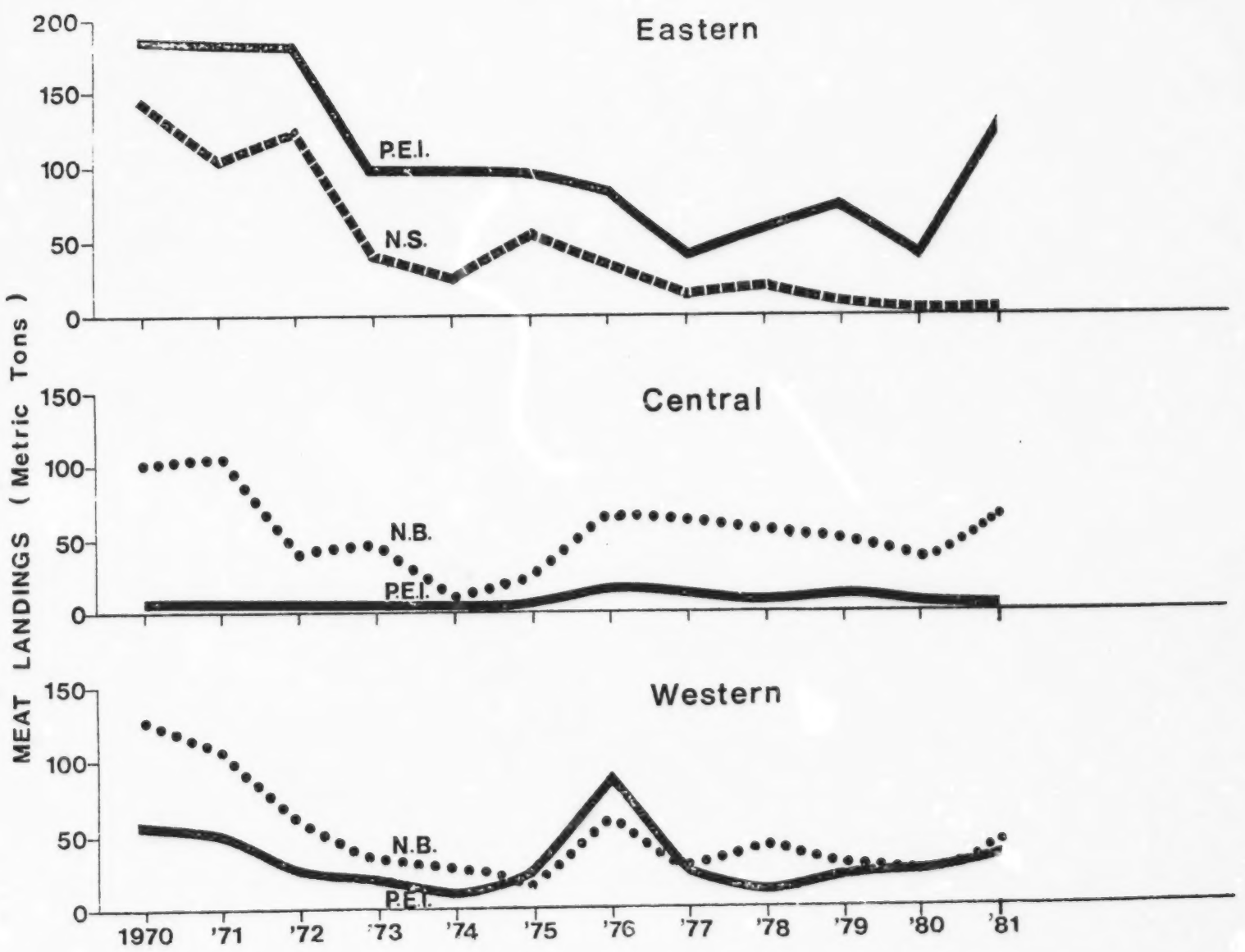

Figure 1. Annual scallop landings by province in the three regions of Northumberland Strait.

Table 1. Regulations (*) and policy applied to the Northumberland Strait scallop fishery in 1981.

	Lobster District 8	Lobster District 7b1
*Season:	April 28-July 28	*April 2-July 15 September 15-December 31
Meat count:	Western 33/lb (36/500 g)	Eastern 47/lb (52/500 g)
:	Central 43/lb (47/500 g)	
Logbooks:	Required	Required
*License:	Freeze on all new entrants	*New entrants permitted if they have fished 30 weeks over the past two years for either lobster or scallop, and are considered a bona fide commercial fisherman.

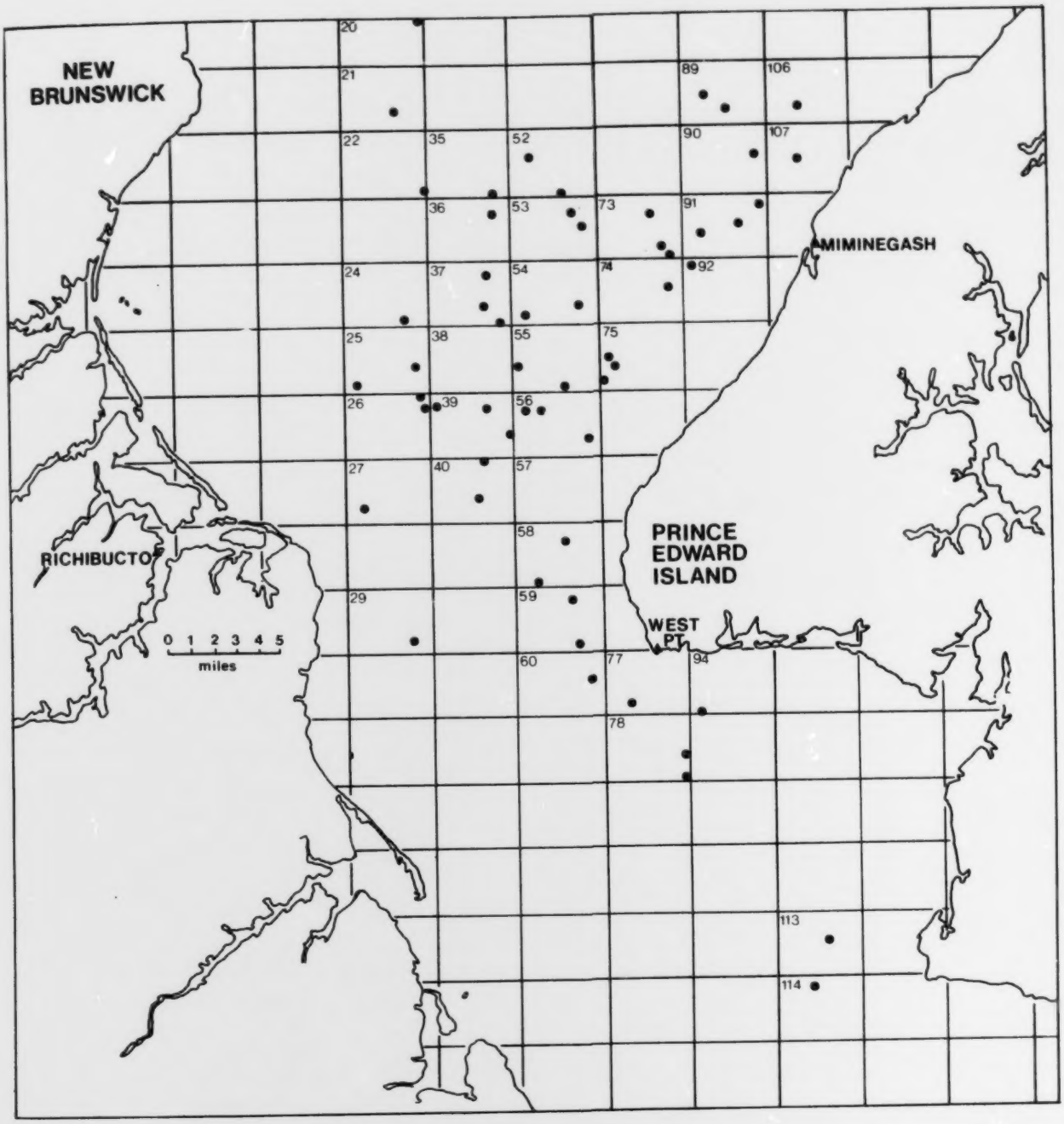

Figure 2. Resource survey station locations in the western Strait. Numbers are area designations.

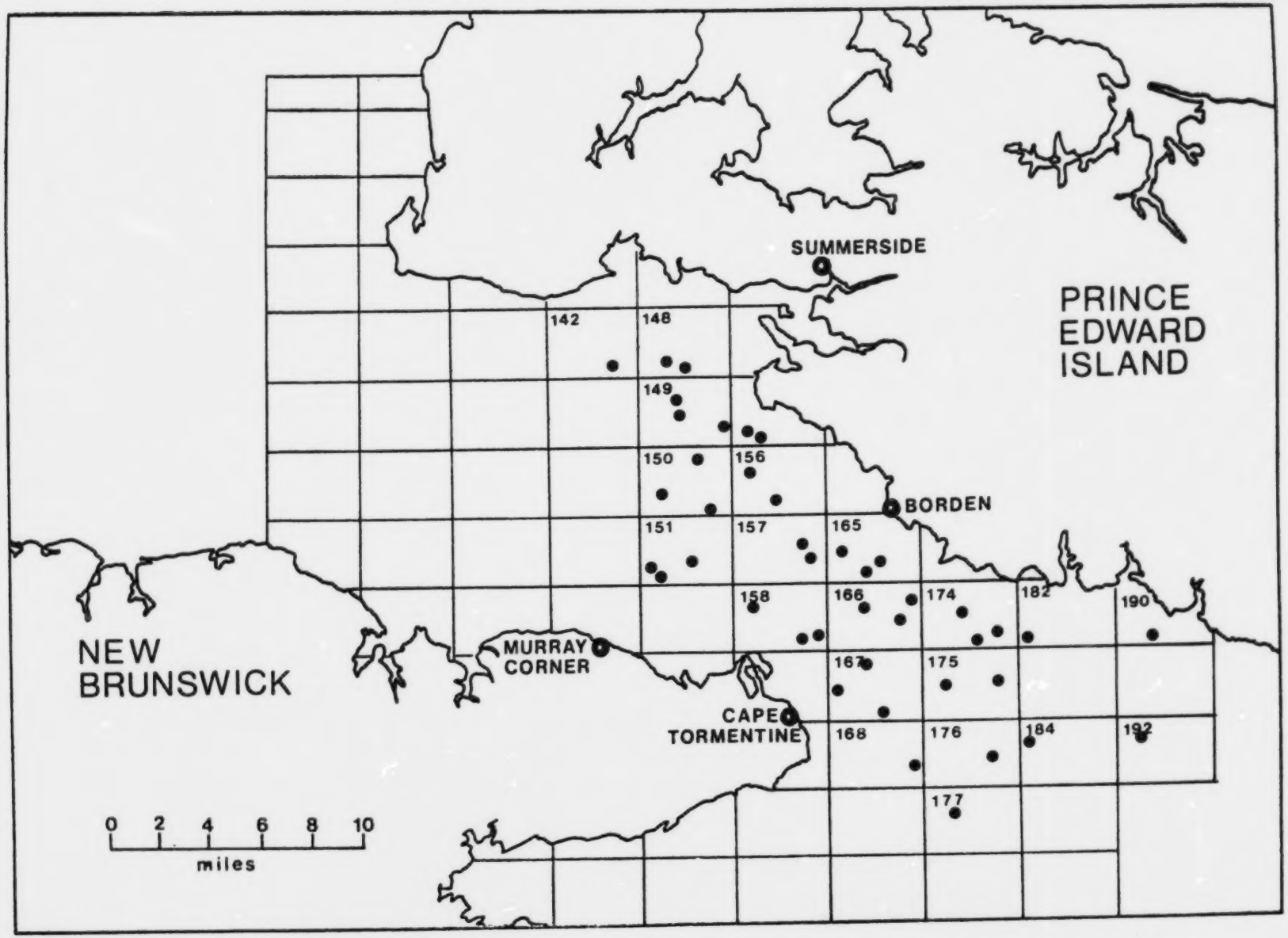

Figure 3. Resource survey station locations in the central Strait. Numbers are area designations.

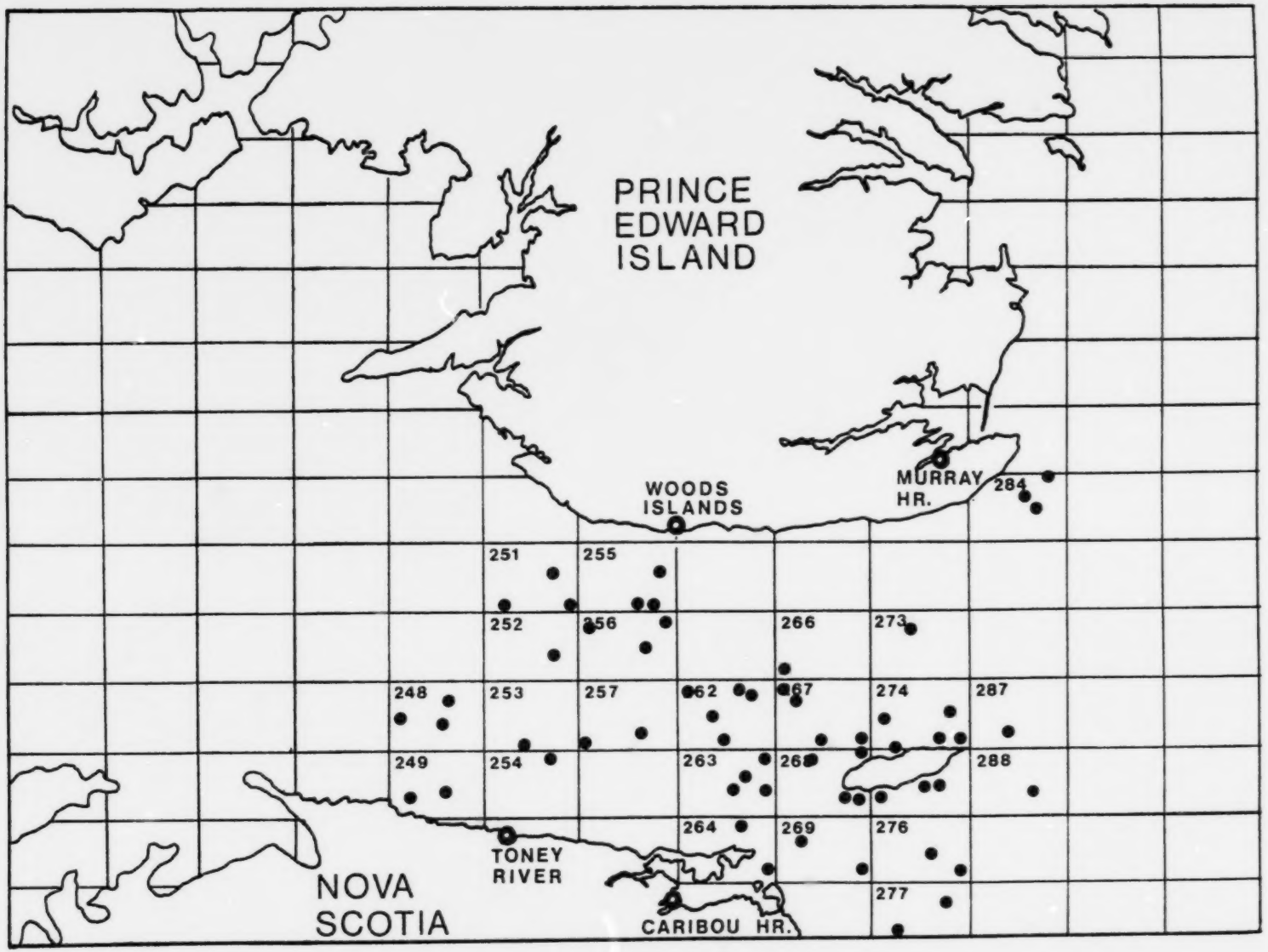

Figure 4. Resource survey station locations in the eastern Strait. Numbers are area designations.

Survey gear (scallop drags) and data recorded for each tow followed similar procedures as Jamieson et al. (1981b). Tow distances averaged 817, 672, and 823 m in the western, central, and eastern Strait respectively. Regardless of distance actually towed, analyses weigh scallop abundance to a tow distance of 800 m.

Scallop age was inferred from shell height according to the von Bertalanffy growth parameters (L_∞ = 126.17 mm, k = 0.206, t_o = -0.362). The following least squares regression was used to determine adductor muscle weight relative to shell height,

$$\ln (\text{weight}) = -10.72 + 2.919 \ln (\text{height})$$

This equation was previously used in 1979 and 1980 studies (Jamieson, 1979; Jamieson et al., 1981a).

Revised areas (km^2) for each survey area and subarea are 30.2 and 7.6 km^2, respectively.

RESULTS

RESOURCE SURVEYS

Total relative prerecruit and recruit abundance by region, strata, and gear type (maximum abundance from either rock or mud drags) is given in Tables 2 and 3. The catch from lined gear was used to estimate relative prerecruit (<4 yr) abundance, whereas the catch from unlined gear was used to estimate relative recruit (≥4 yr) abundance. In the central and eastern regions of Northumberland Strait, average catch (density) of fully recruited scallops was greatest in the high catch stratum. In the western Strait average density of fully recruited scallops was lowest in the high catch stratum with the medium catch stratum having the greatest density. This differs from the results of the 1980 survey and suggests that areas with high commercial catches may have been relatively depleted of scallops. There is a strong possibility that commercial landings from these areas would remain low since few prerecruits have been observed and the remaining fully recruited scallops appeared to be scattered over the area. The relatively strong representation of all fully recruited age classes (Table 4) indicates that the scallop stocks of the eastern Strait fare best among the stocks of the three regions, with recruitment taking place on a regular basis, although not above average, in recent years.

High mortality rates appear to have depleted the 0-1 year-old scallops first observed in 1980 (Jamieson et al., 1981b) in the western Strait. The exceptionally high densities

Table 2. Strata designations and average scallop catch per tow by age grouping in each of the three catch strata in each region of Northumberland Strait, 1981. Abundance of recruits (≥4 yr) was estimated from the catch of an unlined drag, while prerecruits (1-3 yr inclusive) abundance was estimated from the catch of a lined drag. N = total number of areas in a catch stratum per region (cf. Figs. 2-4); N_1 = total number of areas sampled per catch stratum; N_2 = total number of survey stations per catch stratum.

Stratum	%catch stratum (range)	N	N_1	N_2	Age (yr)			Total (recruits)
					1-3	4-7	8+	
WESTERN:								
Low	0.00-1.49	39	17	12	9.1	5.2	9.0	14.2
Medium	1.49-2.99	10	9	21	5.2	8.2	15.2	23.4
High	3+	9	7	23	7.6	4.3	9.9	14.2
CENTRAL:								
Low	0.00-0.99	37	8	8	0.0	1.5	3.9	5.4
Medium	1.00-3.99	8	5	13	0.0	4.3	1.2	5.5
High	4+	8	8	22	2.1	15.0	5.1	20.1
EASTERN:								
Low	0.00-0.99	93	4	13	0.3	0.9	5.4	6.3
Medium	1.00-3.99	12	12	17	1.3	5.5	9.5	15.0
High	4+	8	8	30	15.6	33.5	25.3	58.8

Table 3. Average scallop catch at age per tow for a 4-gang drag in the high catch stratum for lined (A) and unlined (B) rock and mud buckets in the three regions of Northumberland Strait, 1981.

Region and gear type	No. of stations	Age (yr)										
		1	2	3	4	5	6	7	8	9	10	11+
A. LINED GEAR:												
Western												
Rock	23	1	1	3	1	1	1	1	1	1	1	4
Mud	23	1	2	4	1	1	1	1	0	1	1	3
Central												
Rock	22	0	0	1	3	3	3	2	1	1	0	0
Mud	22	0	0	1	1	2	1	1	1	1	0	0
Eastern												
Rock	30	2	3	4	6	7	4	4	4	2	1	5
Mud	30	2	6	5	6	5	2	2	2	2	1	4
B. UNLINED GEAR:												
Western												
Rock	23	0	0	0	0	0	1	2	1	1	1	6
Mud	23	0	0	0	0	0	1	1	0	1	1	5
Central												
Rock	22	0	0	0	1	3	4	3	2	1	1	0
Mud	22	0	0	1	3	5	4	3	2	1	1	0
Eastern												
Rock	30	0	1	3	8	11	8	5	5	5	3	10
Mud	30	0	1	1	2	4	4	2	3	1	1	5

Table 4. Average catch per tow (800 m) of a 4-gang rock drag in each strata in each region. Prerecruits (1-3 yr), lined gear, recruited age groups (≥4 yr), unlined gear.

Region	Strata	No. of stations	Age (yr)										
			1	2	3	4	5	6	7	8	9	10	11+
Western	High	23	1.5	2.2	3.9	0.4	0.5	1.6	1.8	0.7	0.8	1.0	7.4
	Medium	21	1.8	2.0	1.4	1.0	1.9	3.0	2.2	1.8	1.3	1.4	10.6
	Low	12	1.7	5.3	2.2	0.6	1.6	1.6	1.4	2.0	2.1	1.6	3.3
Central	High	22	0.0	0.3	1.7	2.7	4.7	4.5	3.1	2.0	1.4	0.8	0.9
	Medium	13	0.0	0.0	0.0	0.5	1.4	1.9	0.5	0.2	0.1	0.2	0.7
	Low	8	0.0	0.0	0.0	0.0	1.3	0.2	0.0	0.0	0.0	0.4	3.5
Eastern	High	30	3.5	6.4	5.7	7.5	11.3	9.3	5.4	5.9	4.7	3.2	11.5
	Medium	17	0.1	0.4	0.8	0.6	1.6	1.7	1.5	2.1	1.8	1.3	4.2
	Low	13	0.0	0.0	0.3	0.0	0.0	0.4	0.5	0.2	0.1	0.2	4.9

of this year-class were not relocated in 1981 even though tows were repeated on the same ground using Loran C navigational equipment. Some of these scallops were collected alive, but densities were much reduced and large numbers of "cluckers" (dead shell with valves still attached) and separated valves were observed. Some values showed signs of predation by crustaceans (Elner and Jamieson, 1979); however, the actual cause of the year-class disappearance is unknown. The cause may be age- or size-specific since no significant natural mortality appears to have occurred among large-size scallops.

FISHERY CHARACTERISTICS

Participation in the fishery

Entry into the Northumberland Strait scallop fishery is restricted so the number of licenses issued annually varies little. The total number of scallop licenses does not adequately represent the number of active fishermen which, depending on catches and landed value in the scallop and other fisheries, may fluctuate considerably. The number of active fishermen is estimated by statistical district on the basis that the ratio of active fishermen/total annual catch according to sales slips is similar to the ratio of fishermen submitting logbook information/ total annual catch according to logbooks (Jamieson et al., 1981b). This procedure established that, while a 23% increase occurred in fishermen submitting logs, active participation in the fishery increased by 59% (Table 5).

Gear type and size

Information on fishing gear used was provided by 112 fishermen. Weighted average total gear width for rock drags is 3.5 m (Table 6), and despite a wide range of numbers of buckets used (3-12) and mean width (0.76-0.46 m) it varies little (±0.1 m) from year to year. Less fishermen are using mud drags; average total gear width increased slightly to 3.75 m from 3.5 m in previous years.

Catch and effort

Sales slip statistics: Landings statistics by month, province, and lobster district (Tables 7-9) show that landings increased significantly in 1981 compared to 1980. In Lobster District 7b1, total landings increased by over 100% with sustained higher landings every month except November. Catches were reported from four statistical districts where no landings occurred in 1980. Landings more than doubled in the Caribou and Bayfield areas (N.S.), in Buctouche (N.B.), and in Annandale (P.E.I.) districts.

Table 5. Estimated numbers of licensed and active scallop fishermen and the number of fishermen who completed at least one log record in 1980 and 1981. Source: Fisheries Operations Branch, Department of Fisheries and Oceans.

Province	Statistical District	1980			1981		
		Estimated numbers		Number submitting logs	Estimated numbers		Number submitting logs
		Licenses	Active fishermen		Licenses	Active fishermen	
Nova Scotia	2	3	-	-	2	-	-
	3	5	-	-	5	-	-
	10	3	-	-	3	-	1
	11	56	32	20	62	62	36
	12	14	1	1	8	8	2
	13	28	7	3	27	26	4
	45	0	-	-	1	-	-
	46	2	2	2	6	-	-
New Brunswick	75	14	11	5	13	13	7
	76	29	29	8	30	30	7
	77	17	-	5	14	-	-
	78	20	-	-	18	9	3
	80	66	42	19	66	66	36
Prince Edward Island	82	36	22	11	31	30	11
	83	13	-	-	12	-	-
	85	6	4	4	6	6	4
	86	34	19	16	28	26	9
	87	154	88	18	160	123	16
	88	61	-	-	83	10	2
Totals:		561	257	112	575	409	138

Table 6. Individual bucket width and numbers fished in drag gangs by scallop fishermen in Northumberland Strait, 1981.

	No. of buckets	No. of fishermen	Mean bucket width (m)	Std. dev. (m)	Total gear width (m)
Rock drags	3	1	0.76	-	2.28
	4	31	0.74	0.08	2.96
	5	16	0.64	0.12	3.20
	6	19	0.55	0.14	3.30
	7	6	0.47	0.03	2.29
	8	15	0.58	0.06	4.64
	9	1	0.46	-	4.14
	10	2	0.46	-	4.60
	11	-	-	-	-
	12	7	0.46	-	5.52
		98			
Mud drags	1	8	2.97	0.51	2.97
	2	5	2.38	0.14	4.76
	3	-	-	-	-
	4	1	1.22	-	4.88
		14			

Table 7. Monthly scallop landings in Northumberland Strait in 1980 and 1981.

	Landings		
	N.B.	N.S.	P.E.I.
1980:			
April	51,544	3,249	122,844
May	350,628	437	209,479
June	140,163	5,481	103,550
July	34,849	29,579	163,762
August	5,497	-	75
September	1,340	11,828	29,585
October	1,709	48,017	134,271
November	-	51,197	41,027
December	-	-	1,653
Total round weight (kg)*	585,730	149,788	806,246
Meat weight (t)	71	18	97
1981:			
April	96,626	202,074	428,294
May	514,926	28,333	339,989
June	274,354	21,114	196,701
July	32,133	42,114	186,108
August	1,811	-	14,650
September	2,540	38,618	30,428
October	149	75,900	161,367
November	-	25,712	32,503
December	-	-	3,764
Total round weight (kg)	922,539	433,865	1,394,232
Meat weight (t)	111	52	168

Source: Statistics Division, Department of Fisheries and Oceans.
*Conversion coefficient from round weight to meat weight used, 8.3.

Table 8. Regional scallop landings in Northumberland Strait in 1980 and 1981 (round weight, kg).

Province	Statistical District	Lobster District	Representative ports	1980 landings	1981 landings
Nova Scotia	11	7b1	Caribou, Toney River, Cape John	141,960	364,243
	12	7b1	Lismore	-	21,821
	13	7b1	Bayfield, Cribben's Pt.	5,370	38,055
	45	8	Pugwash	1,648	2,838
	46	7b1	Wallace	780	1,773
New Brunswick	73	8	Baie Ste-Anne, Escuminac	-	52,326
	75	8	Cape St. Louis, Kouchibouquac	14,683	13,927
	76	8	Richibucto, Richibucto Cape	179,374	221,776
	77	8	Buctouche	4,799	139,470
	78	8	Shediac, Cap Pelé	51,115	43,227
	80A	8	Murray Corner, Cape Tormentine	335,749	505,481
Prince Edward Island	82A	8	Howard Cove, Miminegash	195,357	328,010
	83	8	Borden	44,820	63,480
	85	7b1	Victoria	2,684	2,191
	86	7b1	Wood Island, Charlottetown	209,740	262,419
	87	7b1	Beach Point, Gaspereau	339,104	685,295
	88	7b1	Annandale	14,541	63,578
	92	7b	Tignish	-	11,259
	93	7b	Conway, Darnley	-	21,137

Table 9. Monthly Northumberland Strait scallop landings in Lobster Districts 7b1 and 8, 1980 and 1981.

	1980		1981	
	Eastern 7b1	Western 8	Eastern 7b1	Western 8
January				
February				
March				
April	108,997	68,640	608,458	118,536
May	61,702	498,842	138,876	744,372
June	47,961	201,203	90,247	401,922
July	181,071	47,109	226,696	33,722
August	-	5,572	14,650	1,811
September	40,950	1,803	68,843	2,743
October	180,995	3,002	235,283	3,475
November	90,850	1,374	57,756	459
December	1,653	-	3,764	-
Total round weight (kg)	714,179	827,545	1,444,573	1,307,040
Meat weight (t)	86	100	174	157

The price per kilogram of scallop meat was above $10 during April and May and never went below $8.50 throughout the fishing season (Table 10). High returns made fishing for scallops attractive to licensed fishermen who had not been participating in the scallop fishery in previous years.

Log record statistics: Completing logs was not a mandatory measure in 1981. The number of fishermen complying has decreased steadily, and only 29% of total catch (from sales slips) was recorded in logs compared to 36% in 1980 (Table 11).

Weighted average CPUE (kg/h-m) for designated log area (Table 12) generally decreased during 1981 in the western and central regions but increased in the eastern region of the Strait. Average CPUE, weighted by catch, for the ten most productive unit areas in each region of the Strait were 1.47 (western), 1.45 (central), and 2.06 kg/h-m (eastern) (Table 13). Average monthly CPUE values weighted by catch (Table 14) showed a mid-summer decline in the eastern Strait. There does not seem to be any distinct CPUE pattern in the western and central Strait. In general, highest monthly CPUE values occurred in the eastern Strait.

The 1981 pattern of distribution of fishing locations is represented as percentages of total regional catch in Figures 5 and 6. Some differences exist over that in 1980 (Jamieson et al., 1981b), especially in the western Strait. Greatest catches originated off western Prince Edward Island from Miminegash to Cape Wolf, with a smaller catch off Red Head in southern Egmont Bay. Little fishing occurred south of Cape Wolf in 1981, yet this area was extensively fished in the fall of 1980. No major change in fishing locations occurred in the central and eastern Strait, areas previously exploited being most heavily fished.

Age composition of the catch

Figures 7 and 8 illustrate the proportion of scallop age classes landed on vessels and in ports respectively. Culling appears to have taken place in the central Strait, but it was barely noted in the western and eastern Strait. However, this observation may result from too small a sample size.

Meat count

Sampling of commercial meat count at landing was carried out on a limited basis in 1981. New Brunswick landings were not looked at and the fall fishery in the eastern Strait was monitored only once (Table 15). Personnel restriction and the wide geographic distribution of the fishery make the collection of biological data difficult. Of an estimated 5,500 vessels-fishing days in 1981, meat counts were obtained from only 102 vessels on nine different dates.

Table 10. Average price (dollars/kg) of scallop meats sold in Northumberland Strait, 1980 and 1981.

Month	1980 Statistical District			1981 Statistical District		
	76	80	87	76	80	87
January						
February						
March						
April		8.27		10.47	10.32	10.10
May	8.64	8.27	8.27	10.17	10.36	10.10
June	8.27	7.72	8.27	9.69	9.78	9.65
July	8.22	7.98	8.11	9.72		9.73
August	7.98	7.72	8.22		10.47	8.82
September			8.27		9.81	9.02
October	7.98	7.96	8.82		10.47	8.55
November	8.71		8.82			8.82
December			9.41			8.82

Table 11. Scallop catch (kg) from sales slip (ss) and log records statistics for each province in each region of Northumberland Strait in 1981 (1980 included for comparison).

		Sales slip catch (kg)	Log records catch (kg)	1981 (%) (log/ss)	1981 (%) (log/ss)
Western	N.B.	45,202	10,415	23	43
	P.E.I.	39,519	14,310	36	49
Central	N.B.	66,109	23,981	36	17
	N.S.	342	0	0	0
	P.E.I.	7,912	2,836	36	39
Eastern	N.S.	51,312	22,745	44	65
	P.E.I.	121,842	23,102	19	34
Total (kg)		332,238	97,389	29	36

Table 12. Landings (kg) and weighted average CPUE (kg/h-m) for each designated log area (see Fig. 5-6) in 1981 where a catch greater than 100 kg was reported to have been fished.

Area (sq. no.)	Landings (kg)	CPUE (kg/h-m)	Area (sq. no.)	Landings (kg)	CPUE (kg/h-m)
0000	6,399.3	-	1500	954.4	1.2
0140	116.1	3.0	1504	332.0	1.2
0160	387.8	1.9	1510	449.1	2.0
0230	225.0	2.6	1512	257.2	1.3
0240	476.7	2.0	1514	108.9	2.4
0250	438.6	1.8	1520	197.3	-
0260	608.7	2.0	1523	157.4	1.1
0280	301.6	1.3	1560	1,990.4	1.5
0340	909.9	2.0	1570	3,717.2	1.5
0370	1,106.3	1.8	1571	342.0	1.2
0380	1,009.7	1.5	1572	108.9	1.4
0390	1,730.5	1.5	1574	479.9	1.8
0400	1,036.9	1.2	1580	610.1	0.9
0410	509.4	0.9	1582	297.1	1.6
0520	147.9	1.9	1590	178.3	-
0530	819.3	1.9	1600	193.2	-
0540	1,229.7	1.2	1620	141.1	1.4
0550	1,180.3	2.4	1650	777.9	1.6
0560	166.5	2.0	1651	209.1	1.5
0570	105.2	1.0	1660	3,151.6	1.2
0580	153.8	-	1661	312.5	1.9
0720	1,133.5	1.0	1662	166.9	1.6
0730	1,831.2	1.5	1663	182.3	1.2
0740	1,092.7	1.3	1664	554.7	3.8
0750	375.1	1.4	1670	426.4	1.0
0770	103.4	-	1672	280.8	1.5
0780	167.8	1.6	1674	356.5	-
0890	274.9	0.7	1740	1,025.6	1.2
0900	646.8	1.1	1750	400.5	0.7
0910	2,718.0	1.4	1751	174.6	1.2
0920	107.5	0.9	1752	240.4	1.5
0930	151.5	1.2	1753	105.2	1.1
0980	317.1	-	1754	133.4	1.6
1110	325.2	-	1760	119.3	0.9
1120	121.1	-	1761	124.7	1.1
1130	108.0	-	1833	100.7	0.7
1140	108.0	-	2110	369.2	-
1240	230.0	-	2230	156.9	3.1
1250	486.3	4.7	2310	217.7	1.1
1260	299.8	-	2320	853.7	1.4
1480	435.0	2.1	2321	123.4	3.7
1490	783.8	2.0	2322	107.5	2.3

.../Contd.

Table 12 Contd...

Area (sq. no.)	Landings (kg)	CPUE (kg/h-m)	Area (sq. no.)	Landings (kg)	CPUE (kg/h-m)
2400	512.6	2.1	2754	532.1	4.4
2510	593.3	2.3	2761	110.2	3.6
2511	152.4	1.4	2762	229.5	3.7
2512	158.3	1.9	2820	215.0	1.7
2520	1,638.4	1.6	2870	562.5	4.2
2524	103.0	-	2940	315.3	-
2550	1,342.6	1.6	2950	128.4	-
2553	199.6	1.8	3010	374.2	2.2
2560	993.4	1.2	3090	608.3	1.6
2561	754.3	2.0	3100	151.5	2.0
2562	540.7	1.7	3110	213.6	2.5
2564	213.6	1.5	3120	274.0	-
2572	598.7	1.9	3240	252.7	2.0
2580	140.6	2.6	3330	329.3	-
2613	152.4	1.7	3930	111.6	-
2614	759.3	1.8	4150	104.3	1.5
2620	2,411.3	1.6	4370	132.0	-
2621	206.4	1.9	4600	108.0	1.9
2622	725.8	1.9			
2624	412.3	2.4			
2630	1,859.7	1.8			
2631	778.4	2.1			
2632	1,321.8	1.9			
2633	386.5	1.4			
2634	263.1	2.0			
2640	171.0	-			
2660	266.7	1.5			
2661	125.2	1.9			
2663	237.2	1.5			
2670	5,166.5	2.1			
2674	181.4	-			
2680	2,358.7	2.6			
2681	288.5	1.4			
2683	253.6	0.4			
2684	182.8	-			
2690	601.5	-			
2730	270.34	1.3			
2734	142.0	-			
2740	5,122.9	2.6			
2741	635.0	2.6			
2742	250.8	2.2			
2743	196.0	1.1			
2750	1,201.6	2.4			

Table 13. Percent of the total catch fished and catch per unit effort (kg meat per hour for each m of drag fished) from the ten most productive unit areas (see Fig. 5-6) in each region of Northumberland Strait as reported by log records in 1981.

	Western			Central			Eastern		
	Sq. no.	%	CPUE	Sq. no.	%	CPUE	Sq. no.	%	CPUE
	91	10.99	1.35	157	17.03	1.48	274	13.70	2.57
	39	7.00	1.54	166	16.29	1.59	267	12.06	2.14
	54	4.97	1.22	156	7.13	1.49	263	10.05	1.84
	55	4.77	2.36	150	4.99	1.28	262	8.27	1.77
	72	4.58	1.03	167	4.36	1.31	268	6.81	2.26
	37	4.47	1.76	174	4.18	1.16	256	5.59	1.54
	74	4.42	1.28	175	3.93	1.17	252	3.91	1.63
	73	4.41	1.48	165	3.87	1.56	255	3.44	1.66
	40	4.19	1.23	158	3.86	1.18	261	2.43	1.79
	38	4.08	1.51	151	3.04	1.82	232	2.37	2.85
Totals:	10	53.88	1.47*	10	68.68	1.45*	10	68.63	2.06*
Total catch (t) meats from log records:		25			27			46	

*Weighted average by catch.

Table 14. Average monthly CPUE values (kg/h-m) weighted by catch for each of the three Northumberland Strait scallop regions, 1980 and 1981.

Month	Western		Central		Eastern	
	1980	1981	1980	1981	1980	1981
April	1.00	1.27	1.60	1.43	1.94	2.07
May	1.33	1.35	1.32	1.57	1.62	1.82
June	1.46	1.36	1.02	1.01	1.38	1.46
July	0.80	-	-	-	1.64	1.54
August	-	-	-	-	-	-
September	0.60	-	-	-	1.21	1.73
October	-	-	-	-	-	1.75
November	-	-	-	-	-	2.37
December	-	-	-	-	-	-

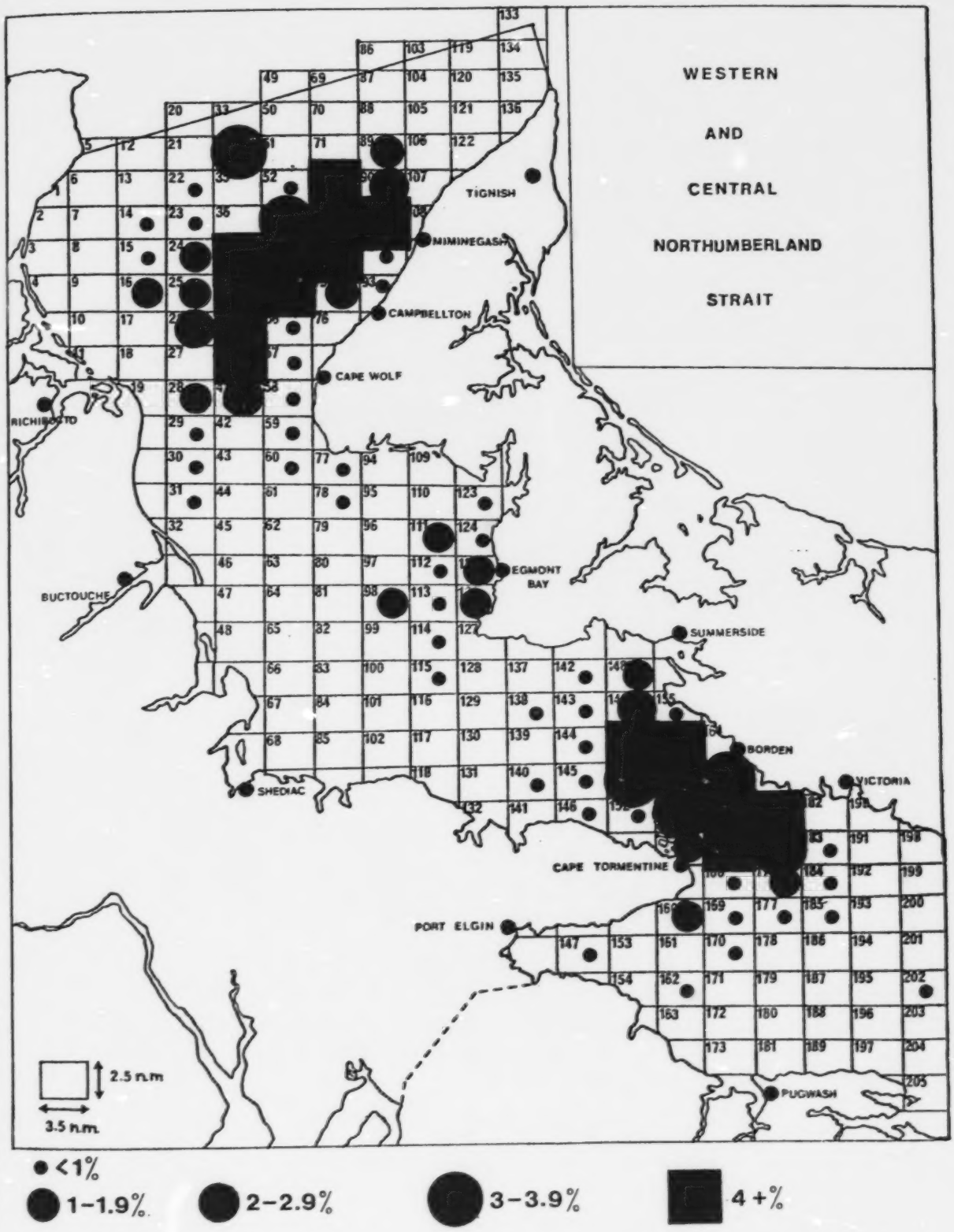

Figure 5. The geographic distribution and relative magnitude (% of total regional catch) of scallop catches in each area in both the western and central regions of Northumberland Strait.

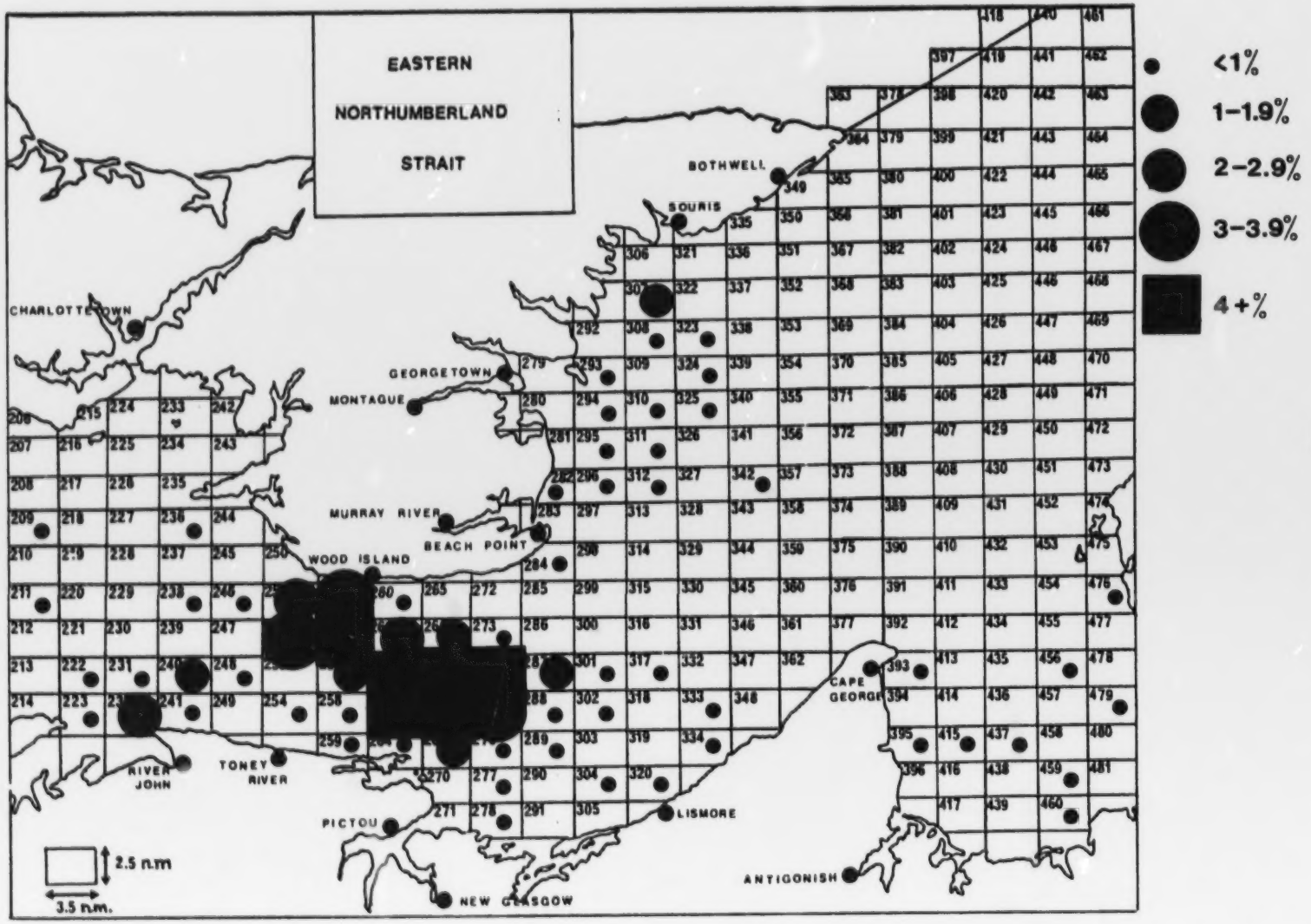

Figure 6. The geographical distribution and relative magnitude (% of total regional catch) of scallop catches in each area of the eastern region of Northumberland Strait.

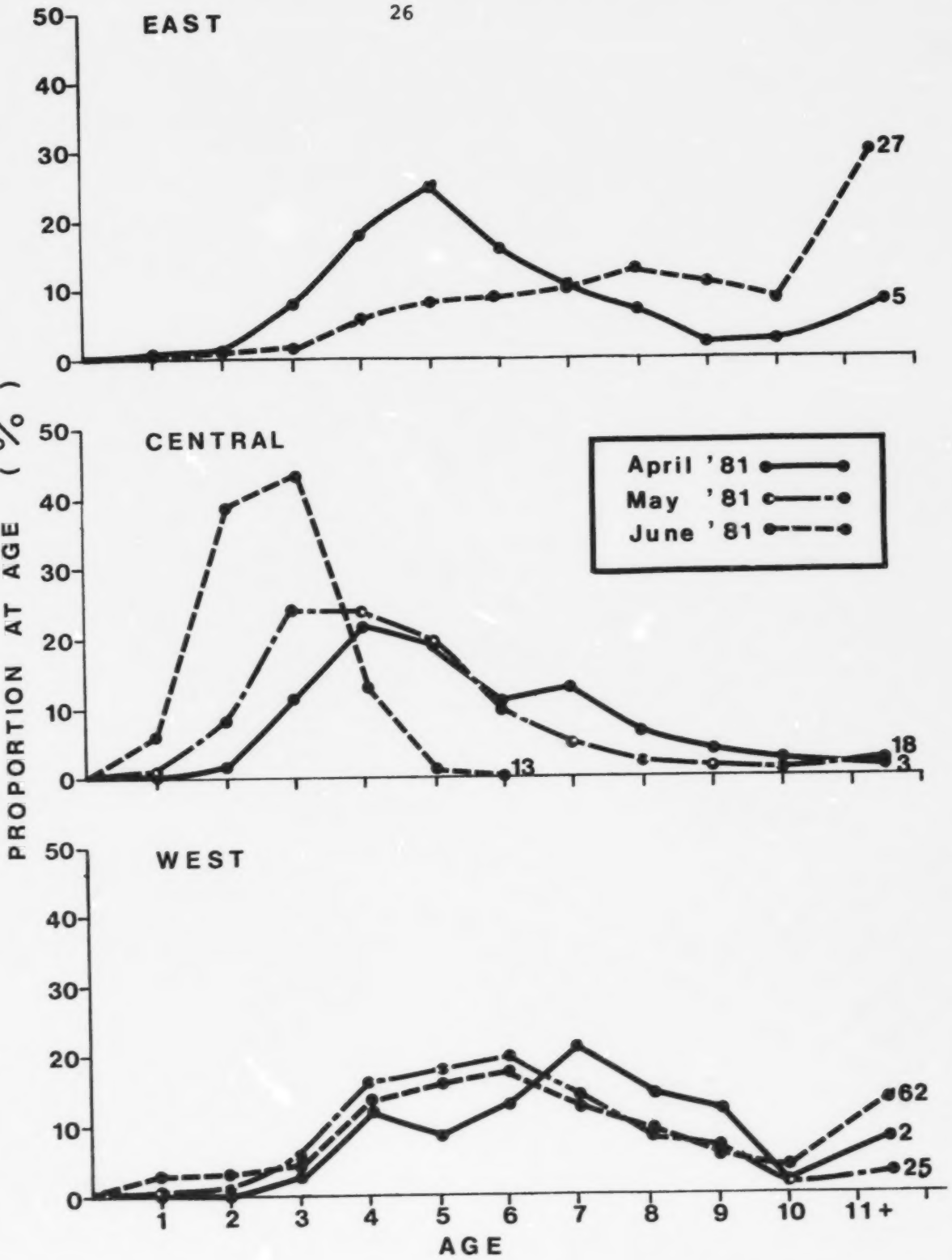

Figure 7. The monthly age frequencies of scallops as landed on vessels in commercial fishing in Northumberland Strait. Values = number of tows.

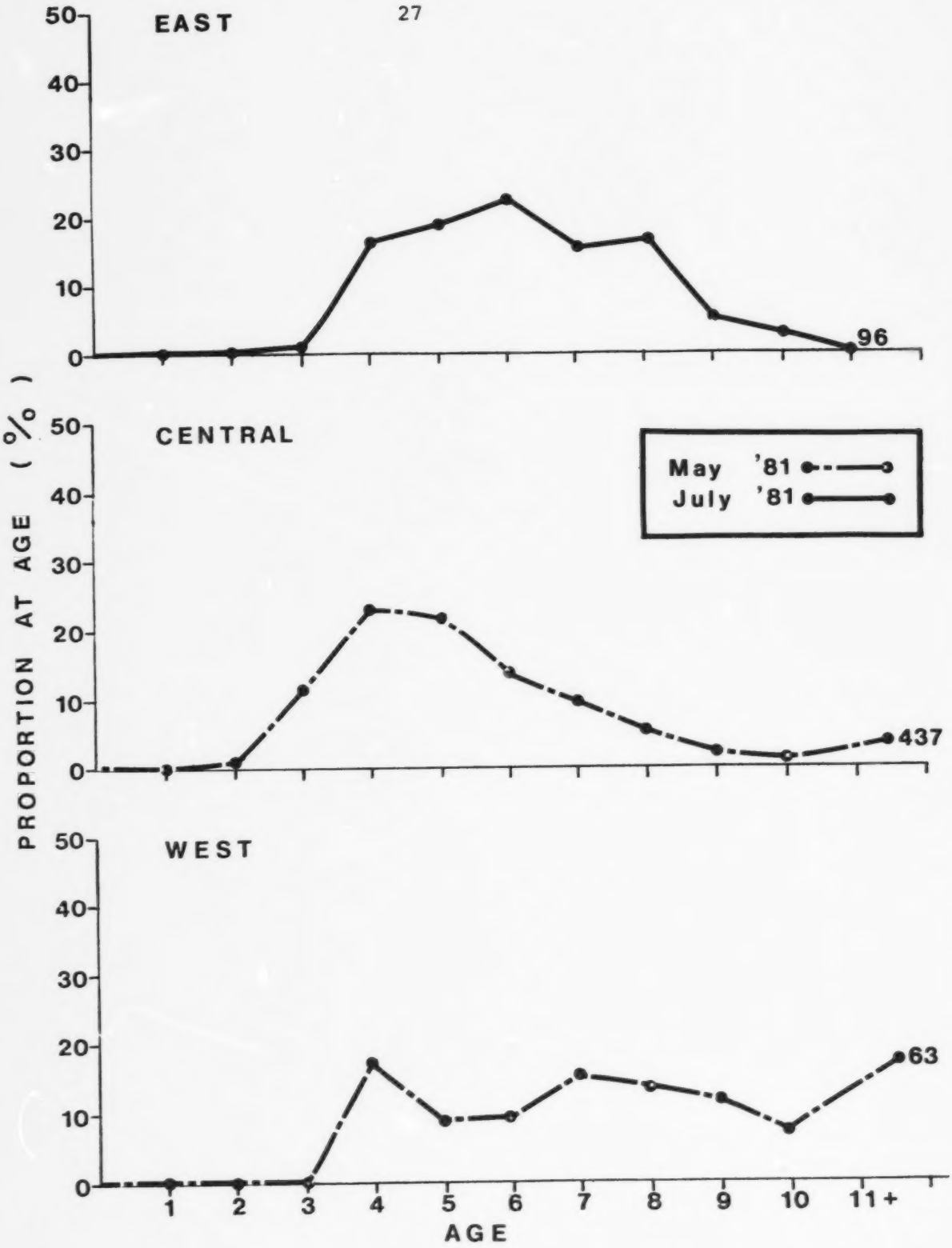

Figure 8. The monthly age frequencies of scallops as landed at port in commercial fishing in Northumberland Strait. Values = number of scallops.

Table 15. Average commercial scallop meat counts (MC) per 500 g in the different regions of Northumberland Strait.

Date	MC per 500 g	No. of boats sampled	Region	Province
26/05/81	14.7	10	Western	P.E.I.
29/05/81	18.0	7	Western	P.E.I.
29/05/81	13.2	8	Western	P.E.I.
05/06/81	35.0	3	Western	P.E.I.
16/06/81	19.5	8	Western	P.E.I.
05/06/81	43.3	4	Central	P.E.I.
08/07/81	44.0	6	Eastern	N.S.
08/07/81	45.0	6	Eastern	N.S.
08/07/81	16.5	6	Eastern	N.S.
09/07/81	45.0	6	Eastern	N.S.
13/07/81	33.0	6	Eastern	N.S.
13/07/81	44.0	6	Eastern	N.S.
13/07/81	33.0	6	Eastern	N.S.
20/07/81	33.0	4	Eastern	P.E.I.
22/10/81	28.7	16	Eastern	P.E.I.

From the limited data available, meat counts in 1981 average 21 meats per 500 g compared to 23 in 1980 for the western Strait, and the fishery depends mostly on age 11+ scallops. In the eastern Strait, there has been an increase in meat counts from 1980, from 28 to 37 meats per 500 g, and age classes (4-8) making up the bulk of the fishery. Data from the central Strait fishery are insufficient for analysis.

DISCUSSION AND CONCLUSIONS

RESOURCE SURVEYS

Relative abundance indices of prerecruits and recruited scallops from the surveys series 1978-81 (Table 16) show that densities of prerecruits are considerably lower than densities of recruits in all cases. The unusually high numbers of precruits (1979 year-class) sampled in 1980 disappeared before the 1981 sampling. Old scallops make up the bulk of the stocks with slow replacement rate throughout the survey period. The relatively low abundance of scallops less than eight years old in the western Strait in 1981 adds support to the conclusion that there has been below-average recruitment to scallop stocks in the western Strait in recent years (Jamieson et al., 1981a and b). Moreover, there is no evidence suggesting when recruitment will improve. Recruitment failure is also a distinct possibility in the central Strait where few prerecruits have been observed and where adult stocks are at low average densities. The situation is less critical in the eastern region.

The causes of recent poor stock recruitment remains unknown. Possible factors contributing to it may include spawning failure, poor larval survival, and juvenile mortality.

Gamete fertilization is external and sexes are separate in this species of scallop, although the occasional hermaphrodite may be encountered (Merrill and Burch, 1960). Unsuccessful spawning might result from insufficient gonad ripening (Medcof and Bourne, 1964), unsynchronized spawning, partial spawnings with the release of too few gametes at any one time, or a population at too low a density to ensure sufficient concentrations of eggs and sperm to achieve an adequate level of gamete fertilization.

The duration of the planktonic stage of scallop larvae in the natural environment is unknown; laboratory experiments at 15°C showed that spatfall occurs 35 days after fertilization (Culliney, 1974). At higher water temperatures (19°C), larvae survival decreased.

Table 16. Resource survey relative abundance indices of prerecruits (PR) (1-3 yr) and recruited scallops (RE) (≥4 yr) for the three regions of Northumberland Strait from 1978 to 1981.

	PR/RE			
	1978	1979	1980	1981
Western	-/14	0/4	26/15	7/18
Central	-/14	1/6	7/39	1/13
Eastern	-/118	3/13	1/14	8/35

1978 data from Jamieson (1979); 1979 data from Jamieson et al. (1981a); 1980 data from Jamieson et al. (1981b); 1981 data, this report.

Adult scallops are intolerant of water temperatures above 20-22°C (Posgay, 1953; Dickie, 1958). High-temperature kills of adults have been reported for the southwestern Gulf of St. Lawrence (Dickie and Medcof, 1963). In the surface layer temperatures reach over 20°C during late summer (Lauzier et al., 1957) when it is believed scallop larvae would occupy this layer. Food shortage and predation may also contribute to a high larval mortality rate. Environmental conditions and overcrowding at settling time may be a key element in the survival rate of scallop spat (Gruffyd and Beaumont, 1972).

Juvenile scallops have a contagious distribution (Jamieson and Chandler, 1980). If an entire year-class is concentrated in only a few locations, excessive mortality from whatever cause may reduce the relative abundance of that particular year-class. That this may actually take place is suggested by the high mortality rate of the 1979 year-class in the western Strait. Such high juvenile mortality might have been naturally induced by unfavorable changes in the physical environment (Dickie and Medcof, 1963) or by predation (Elner and Jamieson, 1979) or by indirect fishing mortality (Medcof and Bourne, 1964). Extensive scallop fishing occurred in May, 1981, in the vicinity of the area where high concentrations of juveniles had been observed; however, the impact of such fishing activities is not clear.

FISHERY CHARACTERISTICS

Participation

Between 1962 and 1972, the number of scallop licenses issued has steadily increased from approximately 50 to 650. However, the nature of the information does not allow identification of active participants. From 1976 on, estimation of the proportion of "active" licenses is possible. In 1978 restricted entry in the Northumberland Strait scallop fishery was implemented; the number of licenses issued annually varied from 525 to 575. But the estimated number of active participants has fluctuated between 257 and 409 (highest in 1981). Participation is related to how financially attractive scallop fishing may be and the relative state of well-being of other inshore fisheries, especially the lobster fishery in Northumberland Strait. This offers an opportunity in the future for multispecies management.

Landings, catch rates, and landed value

For a decade prior to 1981, scallop landings were steadily decreasing in the three regions of Northumberland Strait (Fig. 1) with a minor temporary increase in 1976 for both the western and central regions and a two- to four-fold reduction in

catches from 1973 on in the eastern Strait. Then, in 1981, landings increased in each region, more than doubling in the eastern Strait. A large fraction of scallop catches (up to 30% according to certain sources) are not recorded via sales slips and are difficult to account for.

Catch rate estimated as kilogram of meat per hour for each meter of drag fished is derived from log information. Complying with log completion has been voluntary so far, and the completion rate has deteriorated from 53% in 1979 when it was first started to 29% in 1981. Average CPUE values for the ten most productive unit areas in each region as reported from logs (Jamieson et al., 1981a and b; this paper) increased everywhere in 1980 (from 1979) and again in the eastern region in 1981 while they went down in the other two regions. However, these values (1.25-2.00 kg/h-m approx.) are low or just average relative to other inshore scallop fisheries. Considering that two men fish scallops on each Northumberland Strait vessel and that a Bay of Fundy vessel characteristically has a crew of four, average CPUE values from Bay of Fundy waters would be approximately twice the Northumberland Strait values (unpubl. data). In general, average monthly CPUE values weighted by catch decline as the year progresses, as the probability of unfavorable conditions increases.

Landed value was at an all-time high in April-May, 1981, reaching over $10 per kg; these prices fell down slightly as the season progressed. In previous years, higher prices were usually occurring in November-December. Good prices should have been a strong incentive for the activation of quite a few "back-pocket" (inactive) licenses in the spring of 1981.

The importance of scallop fishing in the three regions of Northumberland Strait has to be evaluated as a component of the southwestern Gulf of St. Lawrence multispecies inshore fisheries. Table 17 provides rate of returns per unit effort (h-m-men) as a measure of productivity of this scallop fishery. Assessed against the productivity of other inshore fisheries, eligible fishermen may or may not elect to participate in the scallop fishery. Ultimately, performance and optimal yields over all inshore fisheries could be improved. According to this three-year data series, scallop fishing is most profitable during the early part and near the end of the fishing year (April to December). On a regional basis this data series indicates that the eastern region is the most productive while the western and central regions average similar returns.

Catch composition

A comparison of age frequencies of scallops landed on vessels against scallops landed in ports shows whether or not

Table 17. Average monthly productivity value (1979 standard $ per h-m-men) for each of the three Northumberland Strait regions in 1979, 1980, and 1981. Productivity value ($/h-m-men) = CPUE value (kg/h-m-men) x landed value ($/kg). All $ values are adjusted to 1979 as a standing unit value according to the $ purchasing power (Statistics Canada).

	District 8						District 7b1		
	Western			Central			Eastern		
	1979	1980	1981	1979	1980	1981	1979	1980	1981
April	-	-	5.39	3.90	6.02	5.98	7.31	-	8.47
May	4.44	5.23	5.56	4.32	4.97	6.59	7.12	6.10	7.44
June	3.86	5.50	5.34	4.75	3.59	4.00	5.33	5.20	5.71
July	3.28	2.99	-	-	-	-	5.87	6.05	6.07
August	-	-	-	-	-	-	-	-	-
September	-	2.18	-	-	-	-	5.02	4.56	6.32
October	-	-	-	3.42	-	-	5.00	6.51	6.06
November	-	-	-	4.36	-	-	5.44	7.63	8.46
December	-	-	-	-	-	-	6.08	8.56	-

the catch gets culled and reveals the relative presence of younger recruited age groups when culling occurs. Over the last few years the average age of scallops fished increased slightly; culling took place in the central and eastern regions but to a lesser extent in the western Strait, the majority of scallop fished being age 11+. The fact that stocks are largely composed of older individuals in the western Strait is reflected in a reduction of the average meat count, down to 21 meats per 500 g in 1981. During that time period, average meat count was rising in the eastern Strait with the inclusion in the fishery of younger recruited age groups.

Distribution of fishing locations

The distribution of fishing locations in Northumberland Strait presented as percentages of total regional catch reveals regional productivity over time and considered over a long term could indicate fishery sustainable levels. On a regional basis, the ten most productive areas provide a high fraction of landings: 49, 70, and 66% in western, central, and eastern Strait respectively. Considering that the size of one unit area is 7.6 km^2, an average 70% of catches in the central region originates from a total area of <80 km^2; the fishery is slightly less localized in the western region. If long-term trends may be modelled after the relatively short-term observations of this study, there are distinctive regional patterns to the Northumberland Strait scallop fishery.

In the western Strait three areas out of the ten most productive ones were fished continuously during the three-year period. If an area were fished consecutively for two years, catches most likely decreased; from 1979 to 1980 average catches dropped from 53 to 41% despite the fact that up to four new areas were fished (Jamieson *et al.*, 1981a and b). Once exploited, stock densities tended to decrease rapidly; and without new recruits fishing activities changed locations. In the central Strait nine out of ten areas were fished year after year. Catches followed small fluctuations on a per-area basis; but overall, fishing grounds <100 km^2 sustained the fishery over recent years. Only half of the most productive areas of the eastern Strait were fished consecutively; fishing new areas generally improved catches; new recruits were added to the catch, as when an area was fished for more than one year catches increased.

Imminent recruitment failure in the western Strait was suggested by the resource surveys even though limited in area and time coverage. This is further supported by the fishery data; mapping fishing activities over a time span of a few years and with wide geographic coverage led to the same conclusions as survey results.

Management options

A review of the recent characteristics of the Northumberland Strait scallop fishery shows that on a historical basis, present fishery performance is at a low level; and continued poor performance, especially in the western Strait, poses serious management problems. Some fishermen allege that the problem is not a difficult one since older, large-meat scallops are relatively abundant. However, they fail to notice the decrease in catches. Recent effort increases and resulting increases in overall catches have further suggested that the stocks can still support a viable fishery. When other Northumberland Strait fisheries do decline, multispecies fishermen develop a strong resistance to have regulations restrict one more fishery.

To optimize yield per recruit, meat count regulations are beneficial but they fail to preserve stock abundance in the absence of recruitment in populations made up largely of old individuals such as in the western Strait. As previously discussed, recruitment failure may result from a number of causes. Management may be instrumental in replenishing stocks by preserving locations of high scallop densities to perhaps facilitate fertilization success and by reducing the opportunity of indirect fishing mortality of juveniles. The establishment of a closed fishing zone was accepted by the then Northumberland Strait Scallop Advisory Committee in June, 1980; but the closure was removed before the fishery started in April, 1981. Some effort restriction is a less effective, second option. Shortening the fishing season by prohibiting fishing during June to September when reproduction processes take place and when fishing productivity values may drop 30% is an alternative. However, it does not facilitate the continued existence of high-density scallop aggregations. There are no simple solutions to this management problem, and corrective measures are usually resented and resisted. Delaying the adoption of conservative measures any further may well mean a fishery collapse in the not-so-distant future.

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